

Digest: Linking coordinated shifts in plant resource allocation to a chromosomal inversion

Abstract:

Local adaptation in plants often requires coordinated shifts among resources. Lowry et al. (2019) provide evidence for physiological and genomic mechanisms underpinning adaptive shifts in yellow monkeyflower (*Mimulus guttatus*), such as the transition between annual and perennial life histories. In *M. guttatus*, differential activity of gibberellins (GA), governed partially by a chromosomal inversion, is responsible for shifts between growth, reproduction, and herbivore defense (secondary compound production).

Main Text:

There is much theoretical debate regarding whether chromosomal rearrangements in plant populations evolve in a purely stochastic or highly adaptive manner. The nature of the effects of chromosomal change may relate in part to the size of the rearrangement, as very small inversions may be likely to evolve purely by genetic drift (Kirkpatrick, 2010). However, linkage of loci by chromosomal rearrangement may be favored by selection over clustering of adaptive loci via successive mutation (Yeaman, 2013). Several molecular mechanisms may underpin the initial inversion event that sometimes but not always involve repetitive elements or duplicated genes at the breakpoints. One major consequence of inversion mutations is the suppression of recombination in heterozygote individuals (Kirkpatrick, 2010). Over time, this suppressed recombination can lead to further divergence between populations and ultimately aid in the speciation process. Other evidence pointing to an adaptive nature of inversions relates to their structured geographical distribution in natural populations, which often links them to climatic variation.

In animal systems, supergenes (gene clusters) and chromosomal rearrangements are known to underpin morphological transitions (e.g. mimicry supergenes in *Heliconius* butterflies; Joron et al., 2011) and social organization (e.g. in the fire ant *Solenopsis invicta*; Wang et al., 2013). In plants, however, one of the clearest links between adaptation and a chromosomal rearrangement can be found in the yellow monkeyflower *Mimulus guttatus*. Coastal and inland populations differ by an inversion known as *DIV1*, which is at least 2.2 Mbp in size (Lowry and Willis, 2010). Coastal populations are perennial, whereas inland populations are mostly annual. These differences in life history strategy are manifested in flowering time divergence and a suite of morphological traits such as stem thickness, internode length, and flower size. Using reciprocal transplant experiments (with different introgression lines), Lowry and Willis (2010) showed directly that the *DIV1* inversion contributed to this shift from perennial to annual life history and consequent adaptation.

In this issue, Lowry et al. (2019) experimentally investigated the link between the *DIV1* inversion and gibberellins (GA), plant hormones that affect plant growth and reproduction. Addition of GA resulted in very different responses in coastal versus inland plants, with large shifts in growth and subsequent morphology in the coastal plants. Lowry et al. (2019) linked the inversion to GA with near-isogenic lines by showing that plants containing the coastal inversion orientation responded significantly more to GA addition than plants containing the inland inversion orientation. This suggests that a reduction in GA activity in perennial coastal ecotypes may contribute to the physiological and evolutionary divergence of the ecotypes. The chromosomal inversion affected not just the abundance but also the composition of

secondary compounds involved in resistance to herbivory. Coastal perennial plants showed elevated levels of phenylpropanoid glycoside synthesis, and similarly the use of introgression lines showed at least a partial link with the *DIV1* inversion.

This study provides further evidence for a link between chromosomal rearrangements and changes in phenotype (i.e. the life history transition from perennial to annual or vice versa). It demonstrates the apparent simplicity of coordinated shifts among resource allocation (i.e. growth, reproduction, and herbivore defense). Accurately dating the origin of the inversion will be necessary to distinguish whether the inversion corresponds directly with a switch to annual life history, or later spread among populations due to natural selection.

References

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